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ABSTRACT

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A Distributed Monitoring and Diagnosis Tool for Real-time Applications

(Developed for the Jet Propulsion Laboratory)

Conventional software methods are not always sufficient for applications that involve demanding real-time constraints in conjunction with intricate reasoning capabilities. One such application area is the monitoring of complex systems. MARVEL is a distributed monitoring and diagnosis too] that combines conventional software with multiple, cooperating knowledge-based systems, It has been developed and successful] y applied to the automation of interplanetary spacecraft operat ions at NASA's Jet Propulsion] laboratory.

MARVEL (Multimission Automation for Real-tiJnc Verification of Engineering 1 ink) is an automated system for telemetry monitoring and analysis, MARVEL has been act ivel y used for mission operations since 1989, It was first deployed for the. Voyager encounter with Neptune and has remained under incremental development since that time, with new deliveries occurring every six to ten months. M ARVEL provides real-time monitoring of dat a from multiple spacecraft subsystems, real-time diagnosis of anomaly conditions, and both real-time and non-real-time productivity enhancement functions (such as trend analysis and report generation). The primary goal of MARVEL is to combine conventional automation and knowledge-based technique.s to provide improved accuracy and efficient in mission operations. A second goal is to demonst rate that incorporate ing artificial intelligence tech - niques into complex real-t imc appl i cat ions can help reduce the need for constant availability y of human expert i se .

MARVI i]. provides user-interface functions, data access, data manipulation, data display, and data archiving within an X-windows/Motif environment. The detailed expertise for anomaly analysis is implemented with hierarchical, embedded, knowledge-based systems, in the event of anomalies, the appropriate knowledge bases provide diagnosis and recommendat ions for correct ive act ion. MARVEL makes it possible for a mission analyst to effectivel y handle significantly more demanding real-t i me sit uat ions than in the past, because it automat i call y performs numerous tasks that previousl y required human effort. As a result of MARVEL, it has become possible for individual analysts to be responsible for several spacecraft subsystems during periods of low and moderate spacecraft activity. This is bc.cause MARVEL reduces both the level of training and the cognitive load that arc required to perform rout i ne mission operat ions.

MARVEL has demonstrated that the use. of automation enhances mission operations. Individual

spacecraft analysts are no longer burdened with routine monitoring, with information gathering, or with preliminary analysis functions. They arc able to view the results of the automation of these activities on displays associated with individual spacecraft. subsystems at the click of a mouse-but[on, This approach has resulted in reduced need for staffing, less workforce dedicated to routine tasks, earlier anomaly detection and diagnosis, leverage of scarce and valuable expertise, and reduced impact from personnel turnover.

As a result, a MARVEL system for the Galileo mission (to Jupiter) is now underway, and a system for experimental U.S. Airforce satellites is under consideration, The commercial potential for satellite monitoring and diagnosis is relative] y obvious, however, the technology developed in MARVEL is relevant to any type of complex system that needs to be monit ored, diagnosed, and/or corrected in real-t i me. Potential applicat ion might include anything from conventional (or nuclear) power plants to transportation systems,

This paper describes details of the MARVEL architecture and implementation, the real-time approaches to artificial intelligence, the benefits of operational USC, and lessons learned in the development process that enable straightforward transfer of MARVEL to other applications.